Alytes, 1996, **14** (1): 42-52.

Use of terrestrial habitats by amphibians in the sandhill uplands of north-central Florida

C. Kenneth Dodd, Jr.

National Biological Service, 7920 N.W. 71st Street, Gainesville, Florida 32653, U.S.A.
kdodd@nervm nerdc.ufl.edu

A total of 506 individuals of 12 amphibian species was captured during sampling of two upland communities in north-central Florida, USA, in 1989 and 1990. Amphibians were found as far as 914 meters from the nearest water body, although the actual breeding site could have been farther away. Of the species dependent on water for breeding, three (*Bufo terrestris, Gastrophryne carolinensis, Scaphiopus holbrooki*) accounted for 87 % of the amphibians captured. No significant correlation was found between the total number of amphibians captured per trap and trap distance to nearest water body. Most amphibians (83 %) were caught less than 600 meters from the nearest water. Upland communities appear to be used extensively by certain amphibians, especially terrestrial burrow users. As such, management programs need to be expanded to include surrounding uplands if amphibian declines are to be prevented.

Introduction

For amphibians that rely on water for reproduction, the vast majority of field studies center on activities at or near breeding sites (e.g., references in Duellman & Trueb, 1985). Amphibians are conspicuous at breeding locations as males call to attract females and establish territories, amplectant pairs mate and deposit eggs, larvae grow and either metamorphose or become neotenes, and adults and metamorphosed young begin to disperse to uplands or other habitats used during non-reproductive times of the year.

The life history of wetland-breeding amphibians away from breeding sites is poorly understood. It seems generally accepted that individuals may disperse some distance from breeding sites, perhaps varying among species, life stages, or in response to quality and availability of adjacent habitats. At least one text, however, terms distances moved into adjacent habitats as "minor" (Zug, 1993). Except for a few studies (e.g., Pearson, 1955; Williams, 1973; Semlitsch, 1981), the presence of water-breeding amphibians in uplands has been inadequately documented in the North American literature, and then often on the basis of a single or relatively few observations on a few species (Table I). The distances that most species in the southeastern United States can or normally disperse are unknown.

Table I. - Examples of distances that North American amphibians have been recorded moving overland under natural conditions. Movements along watercourses and terrestrial movements associated with displacement experiments are not included. *M*, mean.

Species	Location	Movement	Reference
Salamanders			
Ambystoma californiense	California	120 m	HOLLAND et al. (1990)
Ambystoma californiense	California	1600 m[1]	AUSTIN & SHAFFER (1992)
Ambystoma jeffersonianum	Kentucky	M = 250 m	DOUGLAS & MONROE (1981)
Ambystoma jeffersonianum	Indiana	M = 252 m (20-625 m)	WILLIAMS (1973)
Ambystoma jeffersonianum	Indiana	M = 92 m (3-247 m)[1]	WILLIAMS (1973)
Ambystoma jeffersonianum	Michigan	152 m	WACASEY (1961)
Ambystoma jeffersonianum	New York	1610 m	BISHOP (1941)
Ambystoma macrodactylum	California	30 m	STEBBINS (1951)
Ambystoma maculatum	North Carolina	18-823 m	GORDON (1968)
Ambystoma maculatum	Michigan	M = 192 m (157-249 m)	KLEEBERGER & WERNER (1983)
Ambystoma maculatum	Kentucky	M = 150 m (6-220 m)	DOUGLAS & MONROE (1981)
Ambystoma maculatum	Missouri	M = 150 m (to 172 m)	SEXTON et al. (1986)
Ambystoma maculatum	New York	75 m	WILSON (1976)
Ambystoma maculatum	Indiana	M = 64 m (0-125 m)	WILLIAMS (1973)
Ambystoma opacum	Indiana	M = 193 m (0-450 m)	WILLIAMS (1973)
Ambystoma talpoideum	South Carolina	81-261 m	SEMLITSCH (1981)
Ambystoma texanum	Indiana	M = 52 m (0-125 m)	WILLIAMS (1973)
Ambystoma tigrinum	South Carolina	162 m	SEMLITSCH (1983)
Notophthalmus viridescens	Massachusetts	800 m	HEALY (1975)
Frogs			
Acris crepitans	Texas	167 m	PYBURN (1958)
Acris gryllus	Florida	823 m	CARR (1940)
Acris gryllus	Kansas	183 m	FITCH (1958)
Bufo americanus	Minnesota	1000 m	EWERT (1969)
Bufo americanus	Ontario	594 m	OLDHAM (1966)
Bufo cognatus	Minnesota	300-1300 m	EWERT (1969)
Bufo hemiophrys	Minnesota	25 m	OLDFIELD & MORIARTY (1994)
Bufo hemiophrys	Minnesota	61 m	BRECKENRIDGE & TESTER (1961)
Bufo woodhousei	Kansas	579 m	FITCH (1958)
Gastrophryne olivacea	Kansas	to 183 m	FITCH (1956)
Pseudacris nigrita	Kansas	183 m[1]	FITCH (1958)
Pseudacris regilla	Oregon	237 m[1]	JAMESON (1956)
Pseudacris triseriata	Indiana	100 m[2]	KRAMER (1974)
Rana capito	Florida	1600 m	CARR (1940)
Rana capito	Florida	2000 m	FRANZ et al. (1988)
Rana catesbeiana	New York	76 m	INGRAM & RANEY (1943)
Rana catesbeiana	New York	107 m	RANEY (1940)
Rana palustris	Minnesota	500 m	OLDFIELD & MORIARTY (1994)
Rana pipiens	Minnesota	1500 m	OLDFIELD & MORIARTY (1994)
Scaphiopus bombifrons	Kansas	914 m	FITCH (1958)
Scaphiopus holbrookii	Florida	402 m	PEARSON (1955)

[1] Represents juvenile dispersion.
[2] Estimated from map.

In 1989 and 1990, Dodd & Franz (1995) conducted an inventory of the snake community inhabiting upland sites on the Katharine Ordway Preserve in north-central Florida. During the course of the survey, substantial numbers of amphibians were captured in wire mesh funnel traps. Inasmuch as little information was available on the presence of amphibians in these physically harsh environments, I tabulated capture results to determine which species used upland habitats and how far they were from the nearest potential breeding site. Although the original study was not designed to survey the amphibian community, these data may be helpful in planning future research and in directing attention to the importance of uplands in the conservation of amphibian populations that depend upon isolated wetlands for breeding.

Study site and methods

The Katharine Ordway Preserve-Swisher Memorial Sanctuary is a 3750-ha tract located approximately 5 km SE of Melrose, Putnam County, Florida. This upland sandhill region lies within the Interlachen Karstic Highland at the southern end of Trail Ridge. The area represents a portion of a dune complex that probably formed in association with active beach development during periods of higher sea levels (White, 1970). The dunes have been secondarily modified by solution activities in the underlying limestone to form sinkholes and karst basins. Many of these solution features hold water to form ponds, lakes, and wetlands. More than 70 water bodies exist on the property. There are 27 species of amphibians recorded from the Ordway Preserve (Franz, 1995), and at least 16 species have been recorded in a single small temporary pond in upland habitat (Dodd, 1992).

Two of the eight vegetative communities known from the Ordway Preserve (Franz & Hall, 1991) were sampled during this study. Both upland communities, high pine forest and sand live oak hammock, have been influenced by human disturbance and past fire histories Also known as "sandhill", high pine forest is dominated by longleaf pine (*Pinus palustris*), turkey oak (*Quercus laevis*), and wiregrass (*Aristida stricta*). The community occurs on deep sands associated with dune ridges. Sand live oak hammock occurs as fringes around certain wetland types and on ruderal sites. Dominated by sand live oak (*Q. geminata*) and occasionally by laurel oak (*Q. hemisphaerica*), sand live oak hammocks can have dense understories composed of sapling oaks, blueberries (*Vaccinium* spp.), myrtle oak (*Q. myrtifolia*), and other woody plants. Reindeer lichens (*Cladonia* spp. and *Cladina* spp.) and herbaceous species are more prevalent in open hammocks without a dense understory. General information and references on these and other Florida communities are in Myers & Ewel (1990).

Between 15 and 25 % of the property is believed to have been cleared for agriculture and human habitation since 1850 (R. Franz, personal communication). Several of these areas have undergone succession to xeric sand live oak hammocks. Regular prescribed burning of high pine forests was established in 1983 as a part of the Ordway Preserve's management plan for reestablishing the native longleaf pine ecosystem. Summer air temperatures in upland habitats routinely approach 36°C, and substrate temperatures of 50°C have been recorded. The porous sandy soils dry rapidly at and immediately below the surface A combination of poor soil moisture retention and high temperatures at or near the substrate surface make these upland sandhill habitats potentially harsh for small amphibians.

In 1989, 100 individually numbered screen wire mesh double-opening funnel traps (90 cm long by 18 to 25 cm diameter) were placed at six upland sites as follows· 31 traps in closed xeric (sand live oak) hammock; 59 traps in sandhill (high pine) habitat; and 10 traps in open xeric (sand live oak) hammock. Exact locations of the traps and descriptions of the habitats are presented elsewhere (DODD & FRANZ, 1995).

Most traps were set along fallen trees and branches that formed natural drift fences. At certain locations, traps were set along drift fences made of 10 m sections of galvanized metal set in 4-pronged arrays (see figure 1 in CAMPBELL & CHRISTMAN, 1982, and figure 11A in CORN, 1994). All traps were covered with palmetto fronds to prevent captured animals from overheating in the direct sun and to provide cover. In 1989, traps were checked daily from April 4 through November 17 (23,800 trap nights) between 07.00 and 12.00 h. Species identifications were recorded and animals were released in cover within several meters of the trap.

In 1990, the same areas were resampled using the same general techniques except that all sites were not sampled simultaneously In addition, 30 traps were set in closed xeric hammock habitat in the vicinity of a temporary pond (Breezeway Pond). Traps were placed in the same positions as in 1989. From 20 to 30 traps were checked daily from April 4 to September 27. The dates when individual sites were sampled are provided in DODD & FRANZ (1995). This protocol resulted in a sampling period of 4,490 trap nights.

The location of each trap (excluding the Breezeway Pond traps) was plotted on aerial photographs, and the distance to the nearest potential source of water for breeding by amphibians was measured to the nearest meter I examined possible effects of trap placement on amphibian capture in relation to habitat (sandhill, live oak hammock with open understory, live oak hammock with dense understory), type of water body (lake versus pond), and specific water body. Ponds had surface areas less than 4 ha and usually dried during droughts. Although Smith Lake dried during the intense drought of the late 1980's to early 1990's, the other lakes were permanent. Inasmuch as the data were not normally distributed, most comparisons were made using the nonparametric Kruskal-Wallis test (procedure NPAR1WAY, ANONYMOUS, 1988). The effect of trap distance from nearest water body on the total number of amphibians captured was examined using Spearman rank correlation. *Eleutherodactylus planirostris* has terrestrial development and therefore was excluded from analyses of the relationship between trap distance and nearest water body. Statistical analyses were performed using the SAS program for microcomputers (ANONYMOUS, 1988) and ABSTAT version 4 (ANONYMOUS, 1987). The level of significance was set at $\alpha = 0.05$.

RESULTS

A total of 506 amphibians comprising 12 species was captured during trapping for snakes (0.2 amphibians/trap night in 1989, 0.1 amphibians/trap night in 1990). Amphibians were found in funnel traps at distances from 42 m to 914 m from the nearest water (Table II). Individuals were found in 90 different traps; there was no significant difference in mean distance (MD) to nearest water body between funnel traps in which amphibians were caught (MD = 427.9 m) and those in which amphibians were not caught (MD = 334.5 m) (χ^2 = 3.05, 1 *DF*, *P* = 0.08).

Trapping location was not random with respect to water bodies. The mean distance from traps to the nearest water body varied significantly among different ponds and lakes (Table III; χ^2 = 69.4, 5 *DF*, *P* = 0.0001) and in relation to water body type (lakes, MD = 495 m, *N* = 57 traps; ponds, MD = 312 m, *N* = 33 traps; χ^2 = 18.8, 1 *DF*, *P* = 0.0001). Perhaps because of these potential trap biases, there was no significant correlation between the total number of amphibians captured per trap and the distance to nearest water body (fig. 1; r_s = 0.3084, *P* > 0.05, *N* = 100). Likewise, there was no significant difference in the mean distance to nearest water body among the traps in different habitat types (Table IV; χ^2 = 3.3, 2 *DF*, *P* = 0.19).

Only 28 % of the amphibians captured were in traps less than 400 m from the nearest wetland, although 51 % of the traps were less than 400 m from the nearest water body. As distance increased to 500 m (accounting for 77 % of the traps), the amphibian capture percentage increased to 67.6 %, and at 600 m (accounting for 88 % of the traps) the percentage increased to 82.9 %. Few specimens (11) were captured from 600 to 800 m (9 % of the traps), or at distances greater than 900 m (14 amphibians and 2 % of the traps) However, 11.6 % of all captures were recorded from 800 to 900 m; these traps accounted for only 4 % of the trapping effort. Capture was not random with respect to habitat type. More amphibians were captured in open xeric habitat, and less in closed xeric hammock, than might be expected if the number of amphibians captured among habitats was in direct proportion to trapping effort (χ^2 = 10 73, 2 *DF*, *P* = 0.0047) (Table IV).

Discussion

Trap biases exist in the survey protocol, and a rigorous assessment needs to be made concerning factors that influence amphibian presence in upland communities. However, these results suggest that the presence of amphibians in southeastern upland habitats may be more significant than is usually recognized, especially by land and resource managers, and that amphibians occupy habitats even at considerable distances from the nearest potential breeding site. Amphibians captured during the inventory may have bred in more distant wetlands than the nearest wetland to the trap in which they were captured. Therefore, the maximum distances shown in Table II should not be confused with the maximum distances that amphibians are capable of traveling. Likewise, the data in Table IV should not be inferred to mean that amphibians prefer closed xeric hammock to the other habitat types in Florida uplands. These data do suggest avenues for potential research, however.

Although the data are not amenable to analysis of species' preferences because of the biased sampling protocol, it appears that burrow-using terrestrial frogs (toads, spadefoots, narrow-mouthed toads) are more likely than the more arboreal and aquatic species (hylids

Table II. - Species collected and distances (m) from nearest water body for amphibians captured during funnel trapping in upland habitats of north-central Florida, 1989 - 1990. *SD*, standard deviation.

Species	Total number captured	Mean ± *SD* (range)
Acris gryllus	7	383 ± 81.4 (255-492)
Bufo quercicus	15	574 ± 216.8 (404-914)
Bufo terrestris	54	515 ± 202.2 (46-914)
Eleutherodactylus planirostris[1]	91	478 ± 136.7 (46-895)
Gastrophryne carolinensis	162	420 ± 216.8 (42-914)
Hyla cinerea	6	545 ± 181.1 (457-914)
Hyla femoralis	6	266 ± 317.5 (42-815)
Hyla squirella	5	594 ± 188.3 (446-914)
Notophthalmus perstriatus	12	225 ± 180.2 (42-709)
Pseudacris ocularis	1	434
Rana utricularia	1	95
Scaphiopus holbrooki	145	539 ± 211.2 (95-914)

[1] Has terrestrial development.

Table III. - Trap distances (m) in relation to nearest water body on the Ordway Preserve. *SD*, standard deviation.

Name	Wetland type	Number of traps	Mean ± *SD* (range)	Number of amphibians (%)
Blue	Pond	8	461 ± 40.1 (392-511)	15 (3.5)
Enslow	Lake	20	322 ± 46.7 (244-396)	31 (7.2)
Goose	Lake	10	825 ± 75.0 (709-914)	76 (17.8)
One-Shot	Pond	30	264 ± 122.7 (42-469)	91 (21.3)
Ross	Lake	22	501 ± 53.3 (419-610)	180 (42.2)
Smith	Lake	10	420 ± 56.7 (373-533)	64 (15.0)

Table IV. - Amphibian captures in relation to habitat type and trap effort. Data for 1989 captures. *SD*, standard deviation.

Habitat	Number of traps	Distance (m) to water: mean ± *SD* (range)	Number of amphibians (% of capture)
Sandhills	59	432.8 ± 229.5 (41.9-914.4)	248 (58 %)
Closed Xeric Hammock	31	403.0 ± 109.6 (243.8-579.1)	95 (22 %)
Open Xeric Hammock	10	469.0 ± 31.5 (419.1-499.0)	83 (19 %)

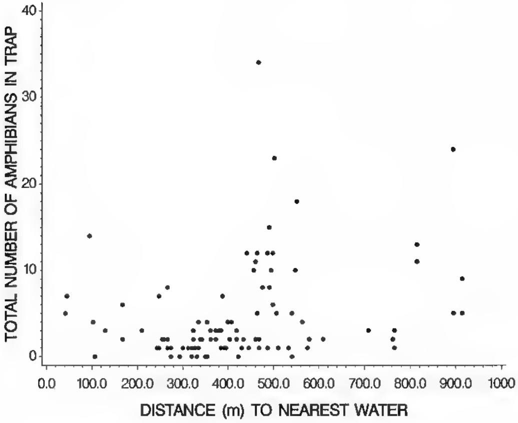

Fig. 1. — The relationship between the total number of amphibians captured in funnel traps and the distance of the funnel trap to the nearest potential breeding site.

and ranids) to be captured by randomly placed terrestrial traps. Arboreal species travel well into uplands in dense oak hammocks surrounding lakes on the Ordway Preserve, but they appear to travel through the tree canopy rather than on the ground (R. BOUGHTON, personal communication). Ranids are also known to make extensive overland movements in Florida uplands (e.g , FRANZ et al., 1988), but their travel routes, time and duration of travel, and susceptibility to trapping are poorly understood.

In upland Florida habitats, amphibians are found in burrows of other animals such as lizards (e.g., *Gastrophryne carolinensis* in the burrows of *Cnemidophorus sexlineatus*), pocket gophers (*Geomys* sp.), and gopher tortoises (*Gopherus polyphemus*), under logs and other surface debris, and in tree cavities (personal observation). Gopher tortoise burrows, in particular, are excellent retreat sites, with nine amphibian species recorded from them (JACKSON & MILSTREY, 1989). The extensive collection of amphibians in funnel traps suggests that these animals are not sedentary but instead leave burrows and other cover sites and move around.

Most North American amphibian field studies involving wetland-breeding species are centered around the breeding site. Such a bias is akin to studying sea turtles only on a nesting beach. Both amphibians and sea turtles spend a great majority of their lives away from the habitats most easily studied by researchers. Just as sea turtle biologists have gained new insights into the life histories of turtles by developing methodologies that allow them to investigate activity away from nesting beaches, amphibian biologists must adopt research methods that begin to probe an amphibian's life away from the breeding pond (DENTON & BEEBEE, 1992; HEYER et al., 1994). Few researchers have conducted field studies of amphibians away from the breeding site (e.g., PEARSON, 1955; DENTON & BEEBEE, 1993; PASANEN et al., 1993; LOMAN, 1994). However, such studies have allowed investigators to take a more holistic view of the ecological requirements and activities of a species.

There has been great concern for the status of amphibian populations and species throughout the world (WAKE et al , 1991; BLAUSTEIN, 1994, BLAUSTEIN et al., 1994). Declines have been reported in a variety of habitats and often have involved wetland-breeding species. Few studies, however, have assessed habitat requirements away from breeding sites. Biologists conducting inventories of upland communities should routinely note the distances to nearest wetlands if wetland-breeding amphibians are found.

Management guidelines that promote wetland protection in order to conserve amphibians yet ignore non-breeding upland habitats (e.g., WILSON, 1994) are destined to failure if resident animals move far from ponds and other wetlands. Buffer zones need to be established around breeding ponds to ensure survival of the amphibian community. In this regard, 82.9 % of the amphibians I captured were within 600 m of the nearest breeding site, although I could not determine if this distance would be effective at protecting the local amphibian community because of the study's sampling biases. DUBOIS (1991: 396) suggested that in tropical regions protection of a buffer zone of 100 to 500 m along each side of watercourses would help conserving a large proportion of the batrachofauna. The need for buffer zones to protect wetland-resident turtle populations has also been recognized (BURKE & GIBBONS, 1995; K. BUHLMANN, personal communication).

Acknowledgments

I thank the Board of the Katharine Ordway Preserve-Swisher Memorial Sanctuary, especially John Eisenberg, for allowing me to carry out these observations on the Preserve. Joseph A. Butler, Richard Franz, Joseph C. Mitchell, and Joseph Pechmann offered helpful comments on the manuscript.

Literature cited

Anonymous, 1987. — *ABSTAT. Release 4.* Parker, Colorado, Anderson Bell: 1-135.

----- 1988. — *SAS/STAT user's guide. Release 6.03 edition.* Cary, North Carolina, SAS Institute Inc.: 1-1028.

Austin, C. C. & Shaffer, H. B., 1992. — Short-, medium-, and long-term repeatability of locomotor performance in the tiger salamander *Ambystoma californiense*. *Funct. Ecol.*, **6**: 145-153.

Bishop, S. C., 1941. — The salamanders of New York. *New York State Mus. Bull.*, **324**: 1-365.

Blaustein, A. R., 1994. — Chicken Little or Nero's Fiddle? A perspective on declining amphibian populations. *Herpetologica*, **50**: 85-97.

Blaustein, A. R., Wake, D. B. & Sousa, W. P., 1994. — Amphibian declines: judging stability, persistence, and susceptibility of populations to local and global extinctions. *Conserv. Biol.*, **8**: 60-71.

Breckenridge, W. J. & Tester, J. R., 1961. — Growth, local movements and hibernation of the Manitoba toad, *Bufo hemiophrys*. *Ecology*, **42**: 637-646.

Burke, V. J. & Gibbons, J. W., 1995. — Terrestrial buffer zones and wetland conservation: a case study of freshwater turtles in a Carolina Bay. *Conserv. Biol.*, **9**: 1365-1369.

Campbell, H. W. & Christman, S. P., 1982. — Field techniques for herpetofaunal community analysis. *In*: N. J. Scott, Jr. (ed.), *Herpetological communities*, U.S. Fish and Wildl. Serv., *Wildl. Res. Rep.*, **13**: 193-200.

Carr, A. F., Jr., 1940. — A contribution to the herpetology of Florida. *Univ. Florida Publ., Biol. Sci. Ser.*, **3**: 1-118.

Corn, P. S. 1994. — Straight-line drift fences and pitfall traps. *In*: W. R. Heyer, M. A. Donnelly, R. W. McDiarmid, L.-A. C. Hayek & M. S. Foster (eds.), *Measuring and monitoring biological diversity — Standard methods for amphibians*, Washington, D.C., Smithsonian Inst. Press: 109-117.

Denton, J. S. & Beebee, T. J. C., 1992. — An evaluation of methods for studying natterjack toads (*Bufo calamita*) outside the breeding season. *Amphibia-Reptilia*, **13**: 365-374.

----- 1993. — Summer and winter refugia of natterjacks (*Bufo calamita*) and common toads (*Bufo bufo*) in Britain. *Herpet. J.*, **3**: 90-94.

Dodd, C. K., Jr., 1992. — Biological diversity of a temporary pond herpetofauna in north Florida sandhills. *Biodiver. and Conserv.*, **1**: 125-142.

Dodd, C. K., Jr. & Franz, R., 1995. — Seasonal abundance and habitat use of selected snakes trapped in xeric and mesic communities of north-central Florida. *Bull. Florida Mus. nat. Hist.*, **31**: 43-67.

Douglas, M. E. & Monroe, B. L., Jr., 1981. — A comparative study of topographical orientation in *Ambystoma* (Amphibia: Caudata). *Copeia*, **1981**: 460-463.

Dubois, A., 1991. — Les amphibiens des régions tropicales: facteurs de déclin et d'extinction. *Cahiers d'Outre-Mer*, **42**: 393-398.

Duellman, W. E. & Trueb, L., 1985. — *Biology of amphibians*. New York, McGraw-Hill, "1986": i-xix + 1-670.

Ewert, M. A., 1969. — Seasonal movements of the toads *Bufo americanus* and *B. cognatus* in northwestern Minnesota. Ph. D. diss., Univ. Minnesota: 1-193.

FITCH, H. S., 1956. — A field study of the Kansas ant-eating frog, *Gastrophryne olivacea*. *Univ. Kansas Publ. Mus. nat. Hist.*, **8**: 275-306.

----- 1958. — Home ranges, territories, and seasonal movements of vertebrates of the Natural History Reservation. *Univ. Kansas Publ. Mus. nat. Hist.*, **11**: 63-326.

FRANZ, R., 1995. — An introduction to the amphibians and reptiles of the Katharine Ordway Preserve-Swisher Memorial Sanctuary, Putnam County, Florida. *Bull. Florida Mus. nat. Hist.*, **31**: 1-10.

FRANZ, R., DODD, C. K., Jr. & JONES, C., 1988. — *Rana areolata aesopus* (Florida gopher frog). Movement. *Herpet. Rev.*, **19**: 33.

FRANZ, R. & HALL, D. W., 1991. — Vegetative communities and annotated plant lists for the Katharine Ordway Preserve — Swisher Memorial Sanctuary, Putnam County, Florida. *Ordway Preserve Research Ser., Rep.*, **3**: 1-65.

GORDON, R. E., 1968. — Terrestrial activity of the spotted salamander, *Ambystoma maculatum*. *Copeia*, **1968**: 879-880.

HEALY, W. R., 1975. — Terrestrial activity and home range in efts of *Notophthalmus viridescens* (Rafinesque). *Amer. Midl. Nat.* **93**: 131-138.

HEYER, W. R., DONNELLY, M. A., MCDIARMID, R. W., HAYEK, L.-A. C. & FOSTER, M. S., 1994. — *Measuring and monitoring biological diversity. Standard methods for amphibians*. Washington, D.C., Smithsonian Inst. Press: i-xx + 1-364.

HOLLAND, D. C., HAYES, M. P. & MCMILLAN, E., 1990. — Late summer movement and mass mortality in the California tiger salamander (*Ambystoma californiense*). *Southwest. Nat.*, **35**: 217-220.

INGRAM, W. M. & RANEY, E. C., 1943. — Additional studies on the movement of tagged bullfrogs, *Rana catesbeiana* Shaw. *Amer. Midl. Nat.*, **29**: 239-241.

JACKSON, D. R. & MILSTREY, E. G., 1989. — The fauna of gopher tortoise burrows. *In*: J. E. DIEMER, D. R. JACKSON, J. L. LANDERS, J. N. LAYNE & D. A. WOOD (eds.), *Gopher tortoise relocation symposium proceedings, Florida nongame Wildl. Prog. tech. Rep.*, **5**: 86-98.

JAMESON, D. L., 1956. — Growth, dispersal and survival of the Pacific tree frog. *Copeia*, **1956**: 25-29.

KLEEBERGER, S. R. & WERNER, J. K., 1983. — Post-breeding migration and summer movement of *Ambystoma maculatum*. *J. Herpet.*, **17**: 176-177.

KRAMER, D. C., 1974. — Home range of the western chorus frog *Pseudacris triseriata triseriata*. *J. Herpet.*, **8**: 245-246.

LOMAN, J., 1994. — Site tenacity, within and between summers, of *Rana arvalis* and *Rana temporaria*. *Alytes*, **12**: 15-29.

MYERS, R. L. & EWEL, J. J., 1990. — *Ecosystems of Florida*. Orlando, Florida, Univ. Central Florida Press: i-xviii + 1-765.

OLDFIELD, B. & MORIARTY, J. J., 1994. — *Amphibians and reptiles native to Minnesota*. Minneapolis, Minnesota, Univ. Minnesota Press: i-xv + 1-237.

OLDHAM, R. S., 1966. — Spring movements in the American toad, *Bufo americanus*. *Can. J. Zool.*, **44**: 63-100.

PASANEN, S., OLKINUORA, P. & SORJONEN, J., 1993. — Summertime population density of *Rana temporaria* in a Finnish coniferous forest. *Alytes*, **11**: 155-163.

PEARSON, P. G., 1955. — Population ecology of the spadefoot toad, *Scaphiopus h. holbrooki* Harlan. *Ecol. Monogr.*, **25**: 233-267.

PYBURN, W. F., 1958. — Size and movements of a local population of cricket frogs (*Acris crepitans*). *Texas J. Sci.*, **10**: 325-342.

RANEY, E. C., 1940. — Summer movements of the bullfrog, *Rana catesbeiana* Shaw, as determined by the jaw-tag method. *Amer. Midl. Nat.*, **23**: 733-745.

SEMLITSCH, R. D., 1981. — Terrestrial activity and summer home range of the mole salamander (*Ambystoma talpoideum*). *Can. J. Zool.*, **59**: 315-322.

----- 1983. — Terrestrial movements of an eastern tiger salamander, *Ambystoma tigrinum*. *Herpet. Rev.*, **14**: 112-113.

SEXTON, O. J., BIZER, J., GAYOU, D. C., FREILING, P. & MOUTSEOUS, M., 1986. — Field studies of breeding spotted salamanders, *Ambystoma maculatum*, in eastern Missouri, U.S.A. *Milwaukee publ. Mus. Contrib. Biol. Geol.*, **67**: 1-19.

STEBBINS, R. C., 1951. — *Amphibians of western North America*. Berkeley, California, Univ. California Press: i-ix + 1-539.

WACASEY, J. W., 1961. — An ecological study of two sympatric species of salamanders, *Ambystoma maculatum* and *A. jeffersonianum* in southern Michigan. Ph.D. diss., Michigan State Univ., East Lansing: 1-129.

WAKE, D. B., MOROWITZ, H. J., BLAUSTEIN, A., BRADFORD, D., BURY, R. B., CALDWELL, J., CORN, P. S., DUBOIS, A., HARTE, J., HAYES, M., INGER, R., NETTMANN, H.-K., RAND, A. S., SMITH, D., TYLER, M. & VITT, L., 1991. — Declining amphibian populations — a global phenomenon? Findings and recommendations. *Alytes*, **9**: 33-42.

WHITE, W. A., 1970. — The geomorphology of the Florida peninsula. *Florida Bureau Geol. Bull.*, **51**: 1-164.

WILLIAMS, P. K., 1973. — Seasonal movements and population dynamics of four sympatric mole salamanders, genus *Ambystoma*. Ph.D. diss., Indiana Univ., Bloomington: 1-57.

WILSON, L. A., 1994. — *The land manager's guide to the amphibians and reptiles of the South*. Chapel Hill, North Carolina, The Nature Conservancy: i-iv + 1-298.

WILSON, R. E., 1976. — An ecological study of *Ambystoma maculatum* and *Ambystoma jeffersonianum* (Amphibia: Caudata). Ph.D. diss., Cornell Univ., Ithaca: 1-125.

ZUG, G. R., 1993. — *Herpetology. An introductory biology of amphibians and reptiles*. San Diego, California, Academic Press: i-xv + 1-527.

Corresponding editor: Janalee P. CALDWELL.